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Information to support the identification of critical habitat for the Morrison Creek Lamprey (*Lampetra richardsoni var. marifuga*)

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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TABLE OF CONTENTS

ABSTRACT iv

RÉSUMÉ v

MORRISON CREEK WATERSHED 1

MORRISON CREEK LAMPREY 3

POPULATION AND STATUS 4

KEY LIFE STAGES AND HABITAT NEEDS 4

- Adult and Metamorphosing Lamprey 4
- Spawning Lamprey and Egg Incubation 5
- Ammocoetes 5

CRITICAL HABITAT 5

- Information, Methods and Approach to Support Critical Habitat Identification for Morrison Creek Lamprey 6
- Information Sources 6
- Approach for Addressing Unique Life History of Morrison Creek Lamprey 6
- Approach for Identifying Geospatial Extent of Critical Habitat for Morrison Creek Lamprey 7
  - Identifying riparian area width 7
- Biophysical Functions, Features and Attributes of Proposed Critical Habitat for Morrison Creek Lamprey 8
  - Stream habitat – Rearing of ammocoetes 12
  - Stream habitat – adult feeding and metamorphosis 12
  - Stream habitat – spawning and egg incubation 12
  - Vegetation in riparian area –All functions 13

GEOGRAPHIC IDENTIFICATION 14

CRITICAL HABITAT IDENTIFICATION IN RELATION TO POPULATION AND DISTRIBUTION OBJECTIVES 15

ACTIVITIES LIKELY TO DESTROY CRITICAL HABITAT 15

RESIDENCE 24

KNOWLEDGE GAPS 25

REFERENCES 25

FIGURES 27

ABSTRACT

Critical habitat is proposed for the Morrison Creek Lamprey in Morrison Creek, on Vancouver Island, British Columbia. The Morrison Creek Lamprey is currently listed as Endangered in Schedule 1 of the *Species at Risk Act*. The Morrison Creek Lamprey is endemic to Morrison Creek and any habitat that is critical for the survival and recovery for this species, must be afforded protection. Given the small size of the Morrison Creek drainage, the distribution of habitats for various life stages of the Morrison Creek Lamprey, the importance of consistent cold water to the continued survival of the species within the creek, and the extreme endemism of this species the critical habitat for the Morrison Creek Lamprey is recommended as the headwaters for the Morrison Creek watershed, Morrison Creek and Arden Creek in its entirety, and a riparian area of between 10 and 30 metres.

Renseignements à l'appui de la désignation de l'habitat essentiel de la lamproie du ruisseau Morrison (*Lampetra richardsoni var. marifuga*)

RÉSUMÉ

L'habitat essentiel est proposé pour la lamproie du ruisseau Morrison dans le ruisseau Morrison, sur l'île de Vancouver, en Colombie-Britannique. Actuellement, la lamproie du ruisseau Morrison est inscrite en tant qu'espèce en voie de disparition à l'Annexe 1 de la *Loi sur les espèces en péril*. La lamproie du ruisseau Morrison est endémique au ruisseau Morrison, et tout habitat essentiel à la survie et au rétablissement de cette espèce doit être protégé. En raison de la petite taille du drainage du ruisseau Morrison, de la répartition des habitats pour les différents stades biologiques de la lamproie du ruisseau Morrison, de l'importance de l'eau froide constante pour la survie continue de l'espèce dans le ruisseau et de l'endémisme extrême de cette espèce, il est recommandé que l'habitat essentiel de la lamproie du ruisseau Morrison comprenne le cours supérieur du bassin versant du ruisseau Morrison, les ruisseaux Morrison et Arden en entier ainsi qu'une zone riveraine de 10 à 30 mètres.

MORRISON CREEK WATERSHED

The Morrison Creek Watershed is located in the Comox Valley, on Vancouver Island. The watershed is approximately 890 ha (Ellefson, 2003) comprised of the headwaters (543 ha) and a series of streams and channels in addition to the wetlands (90 ha). The headwaters are unique as they are contained within a large escarpment. The extent of the drainage into this escarpment is not known. It is believed that water may flow from Maple Lake and possibly other water bodies such as Comox Lake, First Supply Creek and Nellie Creek into the wetland area. Further work is required to determine the precise hydrology of this system. However, it is groundwater from this headwater area which provides water year round to Morrison Creek.

Morrison Creek (23.7 km) extends from the Linton Conservation Area to its confluence with the Puntledge River (Figure 1) in Courtenay. The Linton Conservation Area is within the 543 ha of headwaters. Morrison Creek flows through the jurisdictions of the Village of Cumberland, the Comox Valley Regional District, and the City of Courtenay.

Morrison Creek watershed is located in the coastal Douglas-fir (*Pseudotsuga menziesii*) biogeoclimatic zone. It is comprised of interlinking wetlands, with meadows, thick brush, beaver dams and open beaver ponds. Until approximately one hundred years ago, the Morrison Creek watershed was dominated by large, old growth trees. The entire area was logged, and the resulting forest found in the Morrison / Arden creek watershed today consists of second growth; a mix of big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra)*, and Douglas-fir. It is not known what, if any, effects logging had on the Morrison Creek Lamprey population.

The Linton Conservation area (N 49°39.708', W 125°02.628') is a marsh populated by red alder with salmonberry (*Rubus spactabilis*), buttercup (*Ranunculus* sp.), sedge (*Carex* sp.) and grass (unidentified). The conservation area and the larger watershed area are also home to numerous beaver lodges and several residential homes. The role of beaver lodges and dams is unknown but they may play a significant role in the retention of water in the headwaters area.

Water flows through this area in meandering channels to the outflow under Lake Trail Road by the Inland Island Highway. At this point, it joins the main stem of Morrison Creek and the side channel habitat created for Coho Salmon (*Oncorhynchus kisutch*) when the Inland Island Highway was constructed (1994-1998). This area is surrounded by second growth trees including Douglas-fir (45%), western red cedar (*Thuga plicata*- 45%) and big leaf maple (10%) with undergrowth of thimbleberry (*Rubus parviflorus*), salmonberry, Devil's club (*Oplopanax horridus*), Western sword fern (*Polystichum munitum*) and Oregon grape (*Mahonia aquifolium*). Substrate in the new habitat is mainly mud with small rocks and gravel at the outflow to Morrison Creek. The species of trees and shrubs changes very little along the Creek. The most significant changes are in Roy Stewart Morrison Nature Park (RSMNP) which is composed of large trees (>2 ft diameter) such as hemlock (*Tsuga canadensis*), Douglas fir (dominant), western red cedar, big leaf maple and Coast grand fir *(A. grandis var. grandis*) with undergrowth of salmonberry, Western sword fern, Oregon grape, thimbleberry, huckleberry (*Vaccinium parvifoilum*) and small red alder (*Alnus rubra*). The riparian area (approx. 10 m) around the Creek in the park is populated by Douglas-fir (dominant, 1-2 ft in diameter), small red alder, Western sword fern, Oregon grape, bracken, grass (unidentified), salmonberry and ninebark (*Physocarpus capitatus*).

The majority of Morrison Creek is covered at least partially with the overhanging vegetation mentioned previously. This vegetation shades the majority of the stream, contributing to the large and small woody debris found in the Creek. Morrison Creek varies in width, but is generally narrow, and in areas surveyed was found to be between 2.2 and 6.2 m wide.

The size of the riparian area changes from the headwaters to the terminus at Puntledge Park. This is due to the flow of the creek through rural residential areas of differing age. Areas where new construction near the Creek is ongoing have less dense riparian vegetation than older residential areas and often fewer large trees.

Anthropogenic activities have resulted in alterations to the creek, but their impacts on Morrison Creek Lamprey are unknown. During the early logging years, a sluiceway was cut through what is now Roy Stewart Morrison Nature Park. This has since been filled in but undoubtedly altered flow regimes in this part of the creek. In the early 1980s a diversion channel was created between Morrison Creek and Arden Creek (Figure 2) to increase the Coho Salmon rearing and spawning habitat. The construction of the Inland Island Highway resulted in alterations at the head of Morrison Creek and its adjoining wetlands.

There are several parks and protected areas located along Morrison Creek. The Linton Conservation Area protects some of the Morrison Creek watershed headwaters. Roy Stewart Morrison Nature Park is a large, woodland municipal park of 12.83 hectares, extending along an estimated 0.8 km of Morrison Creek (Figure 2). Puntledge Park is another municipal park located at the terminus of Morrison Creek.

The Morrison Creek stream bed is dominated by compressed till with patches of small gravel and an abundance of stream debris which provide habitat diversity (Beamish *et al.* 1999). Water flows over several substrates including mud, silt, cobble, gravel and boulders. The majority of the Creek has a low to medium flow over small rocks, cobble and gravel. Pools and small riffles dominate with silt collecting in the pools, along the shoreline and any slower moving areas, particularly side channels, which can become muddy.

Morrison Creek drains a small, low relief system and is unlikely to have extremely high flows at any time of year; however the wetland area at the head of the Creek plays a vital role in the continued supply of water. From February 2003 to February 2005 water temperatures fluctuated between 0.0°C to 18.5°C (Figure 3).

Parts of Morrison and Arden creeks are protected within the Linton Conservation Area. There are several wetland areas at the head of Morrison Creek between the Inland Island Highway, Pidgeon Lake Road and Lake Trail Road supplying water for the Morrison/ Arden creek watershed area. Further work is required to determine the precise hydrology of the area including the potential contribution of water from Maple Lake but there are springs at the head of Nelly Creek and 1st Supply Creek that both feed into Morrison Creek. There are numerous small tributaries and side channels within the watershed; these include both natural and man-made channels. Arden Creek enters Morrison Creek a short distance (0.9 km) before its confluence with the Puntledge River. It is unknown whether Morrison Creek Lamprey are found in Arden Creek, although there is little reason to believe they would not be present in this small creek.

A great diversity of species are found within the watershed including large mammals such as black bear (*Ursus americanus*) and Roosevelt elk (*Cervus elaphus roosevelti*), amphibians and crustaceans. Between 2011 and 2013, trap monitors observed signal crayfish (*Pacifastacus leniusculus*) in traps, as well as lamprey which appeared to have been bisected by crayfish. It is unknown if lamprey are a regular prey item for signal crayfish in the creek. Numerous fish species inhabit Morrison Creek, including (*Lampetra richardsoni*), Morrison Creek Lamprey (*L. richardsoni var. marifuga*); Pacific Lamprey (*Entosphenus tridentatus*), Coho Salmon (*O. kisutch*), Pink Salmon (*O. gorbuscha*), Chum Salmon (*O. keta*), Cutthroat Trout (*O. clarkii*) and Rainbow Trout (*O. mykiss*) and the Threespine Stickleback (*Gasterostreus aculeatus*).

MORRISON CREEK LAMPREY

The Morrison Creek Lamprey (*Lampetra richardsoni* var. *marifuga*) is only found in the Morrison Creek watershed, on Vancouver Island (National Recovery Team for Morrison Creek Lamprey, 2007). It is a variety of the Western Brook Lamprey, *L. richardsoni*, which in its most common life history form, is entirely freshwater, non-parasitic and does not feed as an adult.

There are approximately 36 species of lamprey in the world with several new ones currently proposed. A number of these species are termed paired or stem-satellite species. In lamprey in general, paired species are similar morphologically but differ in terms of mode of life, e.g. parasitic vs. non-parasitic. The life history of lamprey can therefore help us understand both their biology as well as taxonomy. Morrison Creek Lamprey is a population which produces two distinct life history types (Beamish *et al.*, 1999), the non-parasitic freshwater *L. richardsoni* and the parasitic freshwater variety *marifuga*. There are no other known living examples of two life history types of the same species of lamprey existing at the same time; making Morrison Creek Lamprey a key to the understanding of lamprey evolution.

Given this is a unique situation and that the typical form of *L. richardsoni* cannot be differentiated from the *marifuga* variety until after metamorphosis, proposed critical habitat that supports all lamprey found in the Morrison Creek watershed is needed. See Information and Methods section below for an expanded discussion of the role that the unique life history of Morrison Creek Lamprey plays in the approach to the identification of critical habitat for the *marifuga* variety.

L. richardsoni spawn in nests constructed by both sexes in fine sediment. After hatching, larvae remain in sediment for several weeks, and then are swept downstream, where they burrow in mud to filter feed on detritus possibly for a period of 3-7 years as ammocoetes, but this is an educated guess (Beamish *et al.*, 1999). Emerging ammocoetes undergo metamorphosis in September, overwinter in gravel, and *L.richardsoni* spawn and die the following May to July (R. Beamish pers. comm., from National Recovery Team for Morrison Creek Lamprey, 2007). It is only after metamorphosis that differences can be distinguished between *L. richardsoni* and *L. richardsoni* var. *marifuga*. At this time, the teeth of *L. richardsoni* var. *marifuga* remain sharp, whereas those of *L. richardsoni* are obsolete as this fish does not feed parasitically. *L. richardsoni* var. *marifuga* is presumed to feed by parasitizing or feeding on a variety of fish species, and in lab studies has been shown to feed and live for up to one year longer than *L. richardsoni*. Unlike typical *L. richardsoni*, *L. richardsoni* var. *marifuga* are silver in colouration and will retain the colour until the end of September (Beamish, 1985; 1987) (Table 1).

Table 1. Key characteristics between L. richardsoni and Morrison Creek Lamprey

Variety	Ammocoete	Adult feeding	Adult colour	Adult spawning
L.richardsoni	Emerge in fall after years in sediment and metamorphose into adult by the summer	Do not feed; Teeth are blunt	Mottled grey; Small eye	Spawn shortly after metamorphosis in the late spring
L.richardsoni var marigua (Morrison Creek Lamprey)	Emerge in fall after years in sediment and metamorphose into adult	Parasitic on unknown fish species; Teeth are sharp	Bright silver; Large eye	Adults feed throughout the summer and spawn the following spring; Lives up to 1 year longer

POPULATION AND STATUS

No quantitative population estimates exist for either the variety *marifuga* or typical *L. richardsoni* in Morrison Creek. However, Beamish (2013) summarizes the catch and biological information of survey efforts from the late 1970s and 1980s. From these data and data from similar catch studies in 2011 (Wade, 2011) and 2012 (Wade, 2012) it can be said that catches of the silver form of Morrison Creek Lamprey have decreased over the past 30 years.

For example, in the 1980s Site 3 was described as the centre of abundance of Morrison Creek Lamprey (Beamish, 2013). Catch per day of the silver form at Site 3 in June and July was 0.93 in 1983, 1.54 in 1984 and 1.05 in 1987 (Beamish, 2013). In 2011 and 2012 this location was not suitable for trapping. Site 2 in 1984 had a catch/day of 0.18 (Beamish, 2013) while the similar location, Site B, in 2012 had a catch/day of 0.02 (Wade, 2012). In 2011, sixteen silver Morrison Creek Lamprey were captured in 102 days (Wade, 2011). In 2012, this number was reduced to 4 in 143 days (Wade, 2012). Compared to 1984, there were 109 silver lamprey captured in 183 days (Beamish, 2013). A further summary of catch rates and locations of sampling efforts from 2011 and 2012 is provided in Wade and Beamish (2014).

KEY LIFE STAGES AND HABITAT NEEDS

ADULT AND METAMORPHOSING LAMPREY

Habitat for the adult (non-spawning) *L. richardsoni var. marifuga* consists of areas of free running fresh water flowing into Morrison Creek, Morrison Creek itself, as well as natural and artificial side channels and tributaries to the Creek. Metamorphosing lamprey are often found in areas of the creek around, or under, large woody debris (LWD), small woody debris (SWD), small boulders and bank overhangs. These areas provide shelter for both adult and metamorphosing lamprey. Recently metamorphosed and metamorphosing lamprey are also found in muddy or silty areas in which they can burrow. All of these types of substrates are found throughout Morrison Creek.

SPAWNING LAMPREY AND EGG INCUBATION

To build their nests, lamprey require pebbles or gravel of a size that can be moved either by mouth or with their bodies. Average oral disc diameter of spawning *L. richardsoni* var. *marifuga* is 1.01cm (Beamish and Withler 1986). Morrison Creek Lamprey build spawning nests in segments of the creek with lower water flow, containing hard substrate covered with small pebbles. Recently, spawned-out lamprey have been captured in passive downstream traps in areas of Morrison Creek possessing these characteristics. Small nests have also been found near trapping locations with lamprey tending some of these nests.

AMMOCOETES

Once lamprey eggs hatch, the ammocoetes burrow into the substrate downstream of the nest. Although it is not known how long *L. richardsoni* var. *marifuga* spend as an ammocoete, it could be estimated to be as long as seven years based on observations of other similar lamprey species (Hardisty and Potter 1971; Potter, 1980; Beamish and Northcote, 1989). Ammocoetes are motile and have the ability to move from place to place actively filter feeding on detritus. It is not known on what types of detritus they are feeding upon. Recent electroshocking surveys showed that ammocoetes were found in low to medium flow areas where the substrate is composed of loose silt, sand or mud (Joy Wade, Fundy Aqua Services, Nanoose Bay, pers. comm.).

CRITICAL HABITAT

Critical habitat is defined in the Species at Risk Act (S.C. 2002, c.29) (SARA) as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species".

The SARA defines habitat for aquatic species at risk as "... spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [s. 2(1)]

Ideally, critical habitat will be identified based on a range-wide analysis of the amount, locations, and attributes of habitat required to meet the population and distribution objectives for the species. However, in the absence of range-wide information, critical habitat must be identified to the extent possible, based on the best available information. In such cases, critical habitat can be partially identified i.e. identified in areas where adequate information is available (DFO 2008).

This paper summarizes the best available information to support the identification of critical habitat that provides the features and functions necessary to support the life cycle-processes of for Morrison Creek Lamprey to the extent possible. It also identifies studies that are required to acquire further information on the features, functions and attributes of the critical habitat for Morrison Creek Lamprey.

It is important to note that despite the use of the term critical habitat in this paper, critical habitat for Morrison Creek Lamprey will only be legally identified once it is included in a final recovery strategy or action plan for the species that is posted on the SARA Public Registry.

INFORMATION, METHODS AND APPROACH TO SUPPORT CRITICAL HABITAT IDENTIFICATION FOR MORRISON CREEK LAMPREY

The identification of critical habitat in the context of SARA must:

- Specify the geospatial location of the critical habitat or describe the area within which critical habitat is found;
- Describe the known biophysical functions, features and attributes of that critical habitat that are required by the listed wildlife species in order to carry out life processes necessary for its survival or recovery;
- Provide a sufficient level of detail to allow a person to determine whether a particular location is part of critical habitat.

INFORMATION SOURCES

There are a several primary publications on *L. richardsoni* var. *marifuga* (Beamish 1985, 1987; Beamish and Withler 1986; Beamish et al., 2001; Beamish, 2013 and; Wade and Beamish 2014) and recent field work (2011-2013) to confirm ongoing presence of lamprey in Morrison Creek.

Beamish (1985 and 1987) describes the evolutionary theory behind the emergence of *L. richardsoni* var. *marifuga*; Beamish and Withler (1986) provide a genetic study of polymorphism in parasitic and non-parasitic lamprey, and Beamish et al. (2001) is the COSEWIC status update of Morrison Creek Lamprey which is the only published paper with any information suitable to aid in critical habitat description. Beamish et al. (2001) showed that Morrison Creek Lamprey cannot osmoregulate in salt water and has been known to live up to one year longer than the common form *L. richardsoni*. The field work by Beamish et al. done in the 1980's is summarized in Beamish (2013) and formed the foundation of the field work undertaken in recent years (Wade 2011, 2012). Wade and Beamish (2014) identifies and describes barriers to lamprey movement in Morrison Creek. The recommendations are currently being acted upon to reduce or mitigate barriers to movement of all lamprey in Morrison Creek.

APPROACH FOR ADDRESSING UNIQUE LIFE HISTORY OF MORRISON CREEK LAMPREY

The proposed critical habitat areas, features, functions and attributes identified in this paper support the life stages of both Western Brook Lamprey and the variety marifuga in Morrison Creek. As these animals cannot be differentiated until after metamorphosis, it is necessary to identify sufficient critical habitat to support all life stages of lamprey including, eggs, larvae and ammocoetes within Morrison Creek. Similarly, as *L. richardsoni* may spawn and produce eggs that could subsequently metamorphose into adults of the variety *marifuga*, it is necessary to identify sufficient critical habitat to support all lamprey spawning in Morrison Creek. The only exception to this approach to critical habitat identification would be the identification of critical habitat features and attributes to support adult feeding which only occurs in the variety *marifuga*.

Another consideration for the approach to critical habitat identification is the fact than an unknown trigger, perhaps environmental, may be responsible for the expression of the variety *marifuga* (Youson, 2004). This suggests that changes to the attributes of the environment and habitat of Morrison Creek Lamprey that exceed the natural range of variation risk eliminating this trigger, which could result in a significant decline in the variety *marifuga*. Beamish (2013) demonstrates an apparent population decline since the 1980s. However, it should be noted that there are few data with respect to the natural range of environmental variation in this watershed.

APPROACH FOR IDENTIFYING GEOSPATIAL EXTENT OF CRITICAL HABITAT FOR MORRISON CREEK LAMPREY

Potential critical habitat for Morrison Creek Lamprey has been identified using the bounding box approach. Critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographic boundaries where the described biophysical features and the functions they support occur.

There are several reasons to support the designation of critical habitat for Morrison Creek Lamprey as the headwater areas, Morrison Creek, Arden Creek and other tributaries and associated riparian area. Particular considerations for this designation include the small size of the drainage (entire watershed is only 890 ha), the extreme endemism of the species, the varied habitat features believed to be required by different life stages of the lamprey, and the distribution of these habitats throughout the creek.

Increased development pressure in the Morrison Creek watershed could result in significant impacts to species habitat and population levels through changes to stream flow, negative impacts to water sources, degradation of riparian vegetation and the introduction of pollutants to the watershed. When dealing with, what is presumed to be a very small and endemic population, any losses of habitat or individuals could have significant implications for the survival of the population. Rosenfeld and Hatfield (2006) argue that the identification of areas of habitat larger than the absolute minimum required for species persistence may be warranted when:

(i) Excluding occupied habitat from protection increases extinction risk for extreme endemics,

(ii) When a critical habitat area is small, and the economic consequences (in terms of lost opportunity costs) of protecting the whole area versus a subset are small;

(iii) When protecting areas at extremely small spatial scales becomes problematic for management purposes; and

(iv) Edge effects may render very small critical habitats ineffectual.

Each of these points is applicable to Morrison Creek Lamprey.

Identifying riparian area width

Riparian areas play an important part in preserving and contributing to the characteristics of aquatic ecosystems. In order to define the width of the riparian area that should be included in the critical habitat being identified for Morrison Creek Lamprey, it is recommended that the British Columbia Riparian Area Regulation (RAR) method be applied to Morrison Creek. The results of this analysis will recommend an area ranging from 10-30 m depending on the area of the stream and its characteristics. This riparian area would apply to Morrison Creek and its tributaries allowing for the maintenance of stream characteristics and critical habitat for Morrison Creek Lamprey.

The RAR method is not without its disadvantages. The primary criticism is that it is not a species specific method, but is designed for salmonids in an urban setting. However, the purpose of the RAR is to "establish directives to protect riparian areas from development so that the areas can provide natural features, functions, and conditions that support fish life processes" and so ensure that "there will be no harmful alteration, disruption or destruction of natural features, functions, and conditions that support fish life processes in the riparian assessment area" (B.C. Reg. 376/2004). If other methods become available which are better suited for the determination of riparian area zones for this species they then can be applied to Morrison Creek and its tributaries.

BIOPHYSICAL FUNCTIONS, FEATURES AND ATTRIBUTES OF PROPOSED CRITICAL HABITAT FOR MORRISON CREEK LAMPREY

The proposed critical habitat described here is believed to be necessary for Morrison Creek Lamprey survival. The location and extent of critical habitat are shown in Figure 4. Table 2 summarizes the best available knowledge of the functions, features and attributes needed for each life-stage of Morrison Creek Lamprey. Note that not all attributes in Table 2 would need to be present in order for a feature to be identified as critical habitat. If the features as described in Table 2 are present and capable of supporting the associated function(s), the feature should be considered critical habitat even though some of the associated attributes might be outside of the range indicated in the table.

Critical habitat for this species includes Morrison Creek, streams and tributaries emptying into Morrison Creek, the headwaters and between 10-30 m of riparian area. This riparian area will provide for trees to fall as LWD and SWD; leaf litter for detritus as well as maintaining bank integrity to ensure clear water flow. The stream and headwaters themselves are the source of free flowing water year round. The ultimate source of the water however is unknown.

It is not currently possible to provide quantitative thresholds for most critical habitat attributes. The authors recommend that further work be undertaken to develop an understanding of such levels and thresholds in quantifiable terms specific to this species.

The quality of the identified critical habitat is unknown but assumed to be variable, affecting local population density and reproductive success. Some areas of critical habitat are probably of lower quality due to natural variation, or the proximity of land-based activities, but they are, nevertheless, necessary for the survival or recovery of the species. It should be noted that because there is little information regarding natural variation in water conditions specific ranges cannot be recommended.

Within the identified geographic boundaries described in the next section, the critical habitat includes the biophysical functions, features and attributes described below.

Table 2. General summary of the biophysical functions, features, attributes and location of potential critical habitat for Morrison Creek Lamprey.

Geographic location	Life stage	Function	Feature	Attribute
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Eggs and larvae	Egg incubation and rearing	Stream habitat	• Pebbles approximately 1 cm diameter • Hard substrate covered with small pebbles/sediment • Free flowing water available year round • Depth 10-25 cm (Stone 2006) • Water quality parameters (oxygen, temperature and pH) within the natural range of variation • Few or no added pollutants • Sedimentation levels within natural variation
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Ammocoete	Feeding and rearing	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate • Free flowing water available year round • Water quality parameters (oxygen, temperature and pH) within the natural range of variation • Few or no added pollutants • Adequate food supply
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Adults	Spawning	Stream habitat	• Pebbles approximately 1 cm diameter for building nests • Hard substrate covered with small pebbles/sediment • Free flowing water available year round • Depth 10-25 cm (Stone 2006) • Water quality parameters (oxygen, temperature and pH) within the natural range of variation • Few or no added pollutants • Sedimentation levels within natural variation
Morrison and Arden creeks and their natural and artificial side channels	Adults	Feeding	Stream habitat	• Availability of food supply of fish (exact species unknown) • Free flowing water available year round • Water quality parameters (oxygen, temperature and pH) within the natural range of variation • Few or no added pollutants

Geographic location	Life stage	Function	Feature	Attribute
and tributaries				• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Metamor-phosing adults	Metamorphosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates • Free flowing water available year round • Water quality parameters (oxygen, temperature and pH) within the natural range of variation • Few or no added pollutants
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Adults and metamor-phosing adults	Feeding and metamorphosis	Vegetation within an appropriately defined riparian area (RAR dependent) from the high water mark on both sides of the channel	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation) • Adequate / stable shade cover for stream habitat • Supply of large and small woody debris and overhanging bank vegetation • Supply of plant litter to contribute to detritus
Morrison and Arden creeks and their natural and artificial side channels and tributaries	Ammocoete	Feeding and rearing	Vegetation within an appropriately defined riparian area (RAR dependent) from the high water mark on both sides of the channel	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation) • Adequate / stable shade cover for stream habitat • Supply of large and small woody debris and overhanging bank vegetation for shelter • Supply of plant litter to contribute to detritus

Geographic location	Life stage	Function	Feature	Attribute
Morrison and Arden creeks and their natural and artificial side channels and tributaries.	Eggs and larvae	Egg incubation and rearing	Vegetation within an appropriately defined riparian area (RAR dependent) from the high water mark on both sides of the channel	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation) • Adequate / stable shade cover for stream habitat • Supply of large and small woody debris and overhanging bank vegetation for shelter • Supply of plant litter to contribute to detritus

Stream habitat – Rearing of ammocoetes

Stream habitat is the biophysical feature that supports the life cycle functions for ammocoetes. In other lamprey species, once the eggs hatch, the ammocoetes burrow into the substrate downstream of the nest. Although it is not known how long Morrison Creek Lamprey spend as an ammocoete, it could be estimated to be as long as seven years based on observations of other, similar lamprey species (Hardisty and Potter, 1971; Potter, 1980; Beamish and Northcote, 1989). In general, ammocoetes are motile and move from place to place actively filter feed on detritus. Recent electroshocking surveys showed that ammocoetes were found in low to medium flow areas of the creek particularly where the substrate was composed of loose silt, sand or mud.

Key attributes:

- Low to medium water flow
- Loose silt, sand or mud substrate in which to burrow
- Free flowing water available year round
- Water quality parameters including oxygen, temperature and pH within the natural range of variation
- Few or no added pollutants
- Adequate food supply of detritus for feeding

Stream habitat – adult feeding and metamorphosis

Stream habitat is the biophysical feature that supports the life cycle function of adult feeding lamprey and metamorphic lamprey. Habitat for the adult (non-spawning) lamprey includes areas of free running water in Morrison Creek, as well as natural and artificial side channels and tributaries and the headwaters. Metamorphosing lamprey can be found in areas of the creek around, or under, large woody debris (LWD), small woody debris (SWD), small boulders and bank overhangs. These areas provide shelter for both adult and metamorphosing lamprey. Recently metamorphosed and metamorphosing lamprey are also found in muddy or silty areas, in which they can burrow. All of these types of substrates can be found throughout Morrison Creek as well as in the headwaters and some tributaries.

Key attributes:

- Free flowing water available year round
- Water quality parameters including oxygen, temperature and pH that remain stable or within the natural range of variation
- Few or no added pollutants
- Adequate supply of large and small woody debris and overhanging bank vegetation for shelter
- Availability of small boulders and bank overhangs or muddy or silty substrates for shelter
- Availability of food supply of fish (exact species unknown)

Stream habitat – spawning and egg incubation

Stream habitat is the biophysical feature that supports the life cycle functions of spawning, egg incubation and ammocoete rearing. To build their nests, lamprey require pebbles of a size that can be moved either by mouth or with their bodies. The average oral disc diameter of spawning

L. richardsoni var. *marifuga* is 1.01cm (Beamish and Withler, 1986), therefore the availability of pebbles with a diameter of approximately 1 cm is an important attribute of this habitat feature.

Morrison Creek Lamprey have been observed in spawning nests in narrower segments of the creek with low flow, containing hard substrate covered with small pebbles. Recently, spawned-out lamprey have been collected from downstream collecting traps in areas of Morrison Creek that possess similar characteristics.

Key attributes:

- Supply of clean pebbles approximately 1 cm diameter for building nests (adult spawning)
- Firm substrate covered with small pebbles for nest building
- Free flowing water available year round
- Low water flow (~0.1 to 0.7 m/s)
- Water depth between 10 and 25 cm (Stone, 2006)
- Water quality parameters including oxygen, temperature and pH within the natural range of variation
- Few or no added pollutants
- Sedimentation levels within natural variation

Vegetation in riparian area –All functions

Vegetation within a riparian area ranging from 10-30 m from the high water mark of either side of the channel is a biophysical feature that supports the life cycle functions of feeding, rearing, spawning, metamorphosis and egg incubation of Morrison Creek Lamprey. This vegetation is also a biophysical feature that directly contributes to the ongoing existence and protection of key attributes of other stream habitat features.

The riparian area is a critical transitional zone between the terrestrial and aquatic ecosystems; and the physical and biological interactions between these two zones are well understood and documented. Pusey and Arthington (2003) provide a comprehensive review of the importance of the riparian area in conservation and management of freshwater fish. They introduce a model ultimately linking the riparian zone to fish assemblage composition, through such pathways as transfer of solar energy to the aquatic ecosystem (thermal energy, shade, instream habitat); exchange of inorganic material between the terrestrial and aquatic ecosystems (interception of terrestrial contaminants, provision of bank stability); and exchange of organic material between terrestrial and aquatic ecosystems (leaf litter, woody debris, root masses, food). These pathways influence water quality, habitat quality & diversity, and trophic dynamics, which either through influencing individual fitness or species diversity, results in the final fish assemblage composition. For fish species, in general, vegetated riparian areas contribute three critical functions: providing streambank stability and water quality (e.g. roots bind soils and prevent erosion and slumping, absorption of pollutants), instream cover (e.g. small and large woody debris, overhanging vegetation), and provision of food (e.g. invertebrate fall, plant litter fall contributing to detritus) (Hatfield, 2009). Riparian areas contribute to the habitat requirements of the Morrison Creek Lamprey in the protection of clear water, free of suspended sediments, the provision of large woody debris, small woody debris and overhanging bank vegetation, as required by adult lamprey; the provision of leaf litter contributing to detritus for ammocoetes; and the provision of pebbles and sediment, to support the nest building activities of the spawning lamprey and egg incubation. Based on the RAR method, a range of between 10

and 30 m riparian area surrounding Morrison Creek and its tributaries is recommended in order to provide these attributes and support these functions for Morrison Creek Lamprey.

Key attributes:

- Stable banks
- Provision of terrestrially supplied food and nutrients
- Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation)
- Adequate / stable shade cover for stream habitat
- Supply of large and small woody debris and overhanging bank vegetation for shelter
- Supply of plant litter to contribute to detritus

GEOGRAPHIC IDENTIFICATION

The following locations of the functions, features and attributes of potential critical habitat for Morrison Creek Lamprey have been identified using the bounding box approach. Critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographic boundaries where the described biophysical features and the functions they support occur. The area within which critical habitat for Morrison Creek Lamprey occurs is identified by the map in Figure 4 and the list of coordinates in Table 3.

Table 3. Coordinate position of Morrison Creek, and associated waterways, stream segments.

NAME	Length (m)	Start Northing	Start Easting	End Northing	End Easting
Morrison Creek	1352.9	-13919580.5068	6387339.9739	-13919093.9168	6386287.4054
Morrison Creek	250.9	-13919707.4219	6387576.3043	-13919640.4059	6387370.4573
Morrison Creek	71.9	-13919774.1406	6387648.8024	-13919724.8324	6387597.3779
Morrison Creek	1003.9	-13916464.0595	6392573.9194	-13916641.8527	6391830.9131
Morrison Creek	798.0	-13918911.1887	6386137.7702	-13918345.0470	6385679.8684
Morrison Creek	252.7	-13919093.9168	6386287.4054	-13918911.1887	6386137.7702
Morrison Creek	41.1	-13916469.2468	6392614.6531	-13916464.0595	6392573.9194
Morrison Creek	5029.8	-13917534.2384	6390985.0601	-13919774.1406	6387648.8024
Morrison Creek	1374.4	-13916641.8527	6391830.9131	-13917534.2384	6390985.0601
Morrison Creek	12.6	-13919716.4584	6387585.1362	-13919707.4219	6387576.3043
Morrison Creek	14.8	-13919724.8324	6387597.3779	-13919716.4584	6387585.1362
Morrison Creek	65.3	-13919638.4632	6387369.3635	-13919580.5068	6387339.9739
Morrison Creek	2.2	-13919640.4059	6387370.4573	-13919638.4632	6387369.3635
Morrison Creek	1905.9	-13918345.0470	6385679.8684	-13916929.5707	6385002.1124
	536.0	-13919047.4224	6385537.1187	-13919554.4200	6385636.2805
Nellie Creek	842.8	-13919690.8755	6387366.4244	-13919940.9313	6386691.2255
First Supply Creek	28.6	-13920003.8865	6387415.1559	-13920017.0291	6387391.4029

NAME	Length (m)	Start Northing	Start Easting	End Northing	End Easting
First Supply Creek	2309.4	-13919983.8182	6387307.3895	-13921572.5336	6386570.7375
	350.5	-13919554.4200	6385636.2805	-13919861.8244	6385655.6246
	224.0	-13919047.4224	6385537.1187	-13919170.7972	6385363.5127
Arden Creek	2323.9	-13916641.8527	6391830.9131	-13917255.5156	6390200.2946
Nellie Creek	354.3	-13919986.9402	6386626.5739	-13920174.9153	6386332.2159
First Supply Creek	62.0	-13920009.9344	6387360.7863	-13919983.8182	6387307.3895
	57.9	-13919350.6300	6385057.1965	-13919404.4534	6385047.9078
First Supply Creek	367.9	-13919770.1676	6387563.8208	-13920003.8865	6387415.1559
	1184.6	-13919538.4261	6387429.3552	-13918680.7462	6386915.7964
	723.1	-13918911.1887	6386137.7702	-13919047.4224	6385537.1187
	692.6	-13918627.6079	6386889.5918	-13918086.1660	6386952.0370
Nellie Creek	79.4	-13919940.9313	6386691.2255	-13919986.9402	6386626.5739
First Supply Creek	31.4	-13920017.0291	6387391.4029	-13920009.9344	6387360.7863
	59.2	-13918680.7462	6386915.7964	-13918627.6079	6386889.5918
Willemar Creek	723.6	-13917534.2384	6390985.0601	-13917660.2431	6390390.4173
	124.7	-13919638.4632	6387369.3635	-13919538.4261	6387429.3552
Nellie Creek	51.0	-13919640.4059	6387370.4573	-13919690.8755	6387366.4244
First Supply Creek	49.9	-13919722.9375	6387579.0054	-13919770.1676	6387563.8208

CRITICAL HABITAT IDENTIFICATION IN RELATION TO POPULATION AND DISTRIBUTION OBJECTIVES

The recovery goal for Morrison Creek Lamprey is to secure its long-term viability within its natural range. The suggested critical habitat will support achieving this goal.

ACTIVITIES LIKELY TO DESTROY CRITICAL HABITAT

Concern has been raised over the impact of anthropogenic activities such as urbanization, agricultural development and logging on the ecological integrity of Morrison Creek as well as to flow regimes in the watershed (Ellefson, 2003). Table 4 provides the general activity, pathway of affect and associated critical habitat parameter that may be impacted.

Activities that are likely to permanently or temporarily destroy critical habitat for Morrison Creek Lamprey include but are not limited to the following:

- Land development for residential or industrial purposes (e.g. improper residential construction practices, improper logging practices, brushing, road building, stream crossings and transmission routes)
- Alteration of stream bed composition to better suit salmonids
- Excessive water extraction and/or impoundment resulting in changes to water levels
- Vehicle spills, illegal dumping

- Residential septic seepage, fertilizer application (commercial or residential)
- Unauthorized aquatic species transfer or stocking; pet and aquarium releases; unintentional species transfer from outdoor ponds ; deliberate or malicious introduction
- Human activities that impact prey species abundance (e.g., recreational and commercial fishing, habitat degradation and destruction) could directly affect abundance of Morrison Creek lamprey.

Table 4. Activities likely to result in the destruction of critical habitat

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
Land-based activities which have the capacity to alter aquatic habitat directly or indirectly Riparian vegetation removal within the defined areas around the stream and inflowing streams	Land development for residential or industrial purposes (e.g. improper residential construction practices, improper logging practices, brushing, road building, stream crossings and transmission routes)	Impacts to riparian habitat, alteration of run-off rates or water storage capacity in headwaters that impact water flow Changes to water quality through introduction of pollutants Reduction in bank stability leading to an increase in sediment inputs to water, which could: - Change aquatic vegetation cover or the food and nutrient regime. - Reduce vegetative cover from predators and terrestrially-derived food. - Increase amount of sunlight reaching the stream or marsh enhancing algal production and leading to temporary loss of habitat. - Alter water quality (e.g. nutrients, sediment, turbidity, etc.)	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply
			Adult feeding and metamorphosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation	Stream habitat	• Supply of pebbles approximately 1cm in diameter for building nests • Substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation
			All	Riparian habitat	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation • Supply of plant litter to contribute to

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
					detritus
Activities that generate significant sediment inputs into adjacent water bodies	Land development for residential or industrial purposes (e.g. improper residential construction practices, improper logging practices, brushing, road building, stream crossings and transmission routes)	Although turbidity values cannot be provided at this time, significant sediment influx into the stream could impair the osmoregulatory capacity of Morrison Creek Lamprey	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply
			Adult feeding and metamor-phosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation	Stream habitat	• Supply of clean pebbles approximately 1cm in diameter for building nests • Firm substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
Stream alterations for salmon habitat enhancement	Alteration of stream bed composition to better suit salmonids	Stream alterations resulting in reduction of available suitable habitat for Morrison Creek Lamprey	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply
			Adult feeding and metamor-phosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation	Stream Habitat	• Supply of clean pebbles approximately 1cm in diameter for building nests • Substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation
Water withdrawals and/or impoundment	Excessive water extraction and/or impoundment resulting in changes to water levels	Water fluctuations that are greater than natural variability which could alter water flow in Morrison Creek	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply of detritus for feeding

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
			Adult feeding and metamor-phosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation	Stream habitat	• Supply of pebbles approximately 1cm in diameter for building nests • Firm substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation
			All	Riparian habitat	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation • Supply of plant litter to contribute to detritus
Release of deleterious substances	Vehicle Spills, Illegal dumping	Polycyclic Aromatic Hydrocarbons (PAHs) do not readily dissolve in water but will bind with organic material and can be deposited in the sediment which could affect adult feeding and metamorphosis as well as	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
		rearing of ammocoetes and egg incubation.	Adult feeding and metamor-phosis		• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation		• Supply of clean pebbles approximately 1cm in diameter for building nests • Firm substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation
Excessive nutrient input through groundwater and/or surface flows from point or non-point sources	Residential septic seepage, fertilizer application (commercial or residential)	Eutrophication resulting in algal blooms reducing light penetration, water clarity, changing water chemistry, increased sedimentation rates, altered food web structure	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply
			Adult feeding and metamor-phosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
			Spawning and egg incubation	Stream habitat	• Supply of clean pebbles approximately 1cm diameter for building nests • Firm substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation
Introduction of invasive species through human activities	Unauthorized aquatic species transfer or stocking; pet and aquarium releases; unintentional species transfer from outdoor ponds ; deliberate or malicious introduction	Modification of predator/prey relationships; displacement from habitat leading to recruitment failure	Rearing of Ammocoetes	Stream habitat	• Low to medium water flow • Loose silt, sand or mud substrate in which to burrow • Free flowing water available year round • Water quality parameters including oxygen, temperature and pH within the natural range of variation • Few or no added pollutants • Adequate food supply
			Adult feeding and metamor-phosis	Stream habitat	• Adequate supply of large and small woody debris and overhanging bank vegetation • Availability of small boulders and bank overhangs or muddy or silty substrates for shelter • Availability of food supply of fish (exact species unknown)
			Spawning and egg incubation	Stream habitat	• Supply of clean pebbles approximately 1cm in diameter for building nests • Firm substrate covered with small pebbles for nest building • Low water flow (~0.1 to 0.7 m/s) • Water depth between 10 and 25 cm • Sedimentation levels within natural variation

Threat	Activity	Effect Pathway	Function Affected	Feature Affected	Attribute Affected
			All	Riparian area	• Stable banks • Provision of terrestrially supplied food and nutrients • Stable quality and quantity of surface water run-off during high rainfall conditions (within natural range of variation • Supply of plant litter to contribute to detritus
Reduction in prey base	Human activities that impact prey species abundance (e.g., recreational and commercial fishing, habitat degradation and destruction) could directly affect abundance of Morrison Creek lamprey.	Disruption of predator prey relationship leading to impacts on Morrison Creek Lamprey abundance	Adult feeding	Stream habitat	• Availability of food supply of fish (exact species unknown)

RESIDENCE

SARA defines a residence as "a dwelling place, such as a den, nest or other similar area or place that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating" (S.C. 2002, c.29).

The identification of a residence allows for an additional measure of protection within critical habitat. The residence must support a life cycle function, there must be an element of investment into the creation or modification of the structure and it must be occupied by one or more individuals. The designation of residence is similar to critical habitat, whereby a bounding box method will be used and the features of the residence, as well as frequency and period of use must be described.

Morrison Creek Lamprey construct nests where eggs are deposited, fertilized, and incubated prior to hatching (National Recovery Team for Morrison Creek Lamprey, 2007; COSEWIC, 2010). Both sexes of lamprey participate in building the nest before spawning, though males do much of the work (Beamish *et al.*, 1999; COSEWIC, 2010). Nest construction involves the excavation of a small depression by vibrating their bodies and carrying individual pebbles short distances using their oral disc (COSEWIC 2010).

Observations of Western Brook Lamprey spawning behaviour in Washington State showed pairs and groups of adults working together to construct nests (Stone, 2006). Similar spawning activity of lamprey in Morrison Creek has also been observed. Once the nest is complete or almost complete, the female attaches herself to an upstream rock while the male glides his oral disc over her body, then attaches himself to her head and coils his body around her (Stone, 2006; COSEWIC, 2010). Gametes are expressed simultaneously and fertilized eggs fall into the nest where they adhere to the substrate and are subsequently covered by the spawners (Stone 2006; COSEWIC, 2010). Fertilized eggs remain in the nest until they hatch. Nests support the life-cycle functions of spawning and egg incubation for Morrison Creek Lamprey.

The specific locations of Morrison Creek Lamprey nests within the watershed are not known. Spawned-out lamprey and nests have been found in areas of Morrison Creek with low water flow and hard substrate covered with small pebbles (Joy Wade, Fundy Aqua Services, Nanoose Bay, pers. comm.). Western Brook Lamprey nests are typically constructed in sand and gravel substrate (< 2 cm diameter) near the upstream end of a riffle, in the downstream portion of pools or in runs that have a water depth between 10-25 cm (Stone, 2006; McPhail, 2007; COSEWIC 2010). The average oral disc diameter of spawning *L. richardsoni* var. *marifuga* is 1.01cm (Beamish and Withler 1986), therefore the availability of gravel with a diameter approximately 1 cm could be another habitat attribute that helps determine nest location.

Morrison Creek Lamprey begin spawning in April, and spent, dying adults have been captured in downstream traps into July and August. A laboratory study found that Western Brook Lamprey eggs hatched within 30 days at 10°C and 12 days at 22°C (Meeuwig et al., 2005 in COSEWIC, 2010). This further suggests that lamprey nests may be present and in use in Morrison Creek watershed between April and July.

Based on the description above, the nests that Morrison Creek Lamprey construct within the Morrison Creek watershed should be considered residences under SARA while they are being used for spawning or egg incubation (between April and July) because:

- They are discrete dwelling places that have a form and function similar to that of a nest;

- Adult lamprey of both sexes make an investment in creating a nests by using their bodies to excavate the depression and their oral disc to carry pebbles for the nest;
- The nests have the functional capacity to support the essential life-cycle processes of spawning and egg incubation;
- The nests are occupied by multiple individuals during spawning and egg incubation.

KNOWLEDGE GAPS

- Morrison Creek Lamprey population abundance estimates
- Morrison Creek Lamprey prey identification and estimate of prey abundance
- Increased understanding of habitat use by different life stages of Morrison Creek Lamprey including the identification of spawning locations
- Determination of the potential relationship between habitat and abundance
- Unknown hydrological connectivity in the headwaters area
- Determination of genetic relationship within and between lamprey populations in Morrison Creek and other streams in British Columbia

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FIGURES

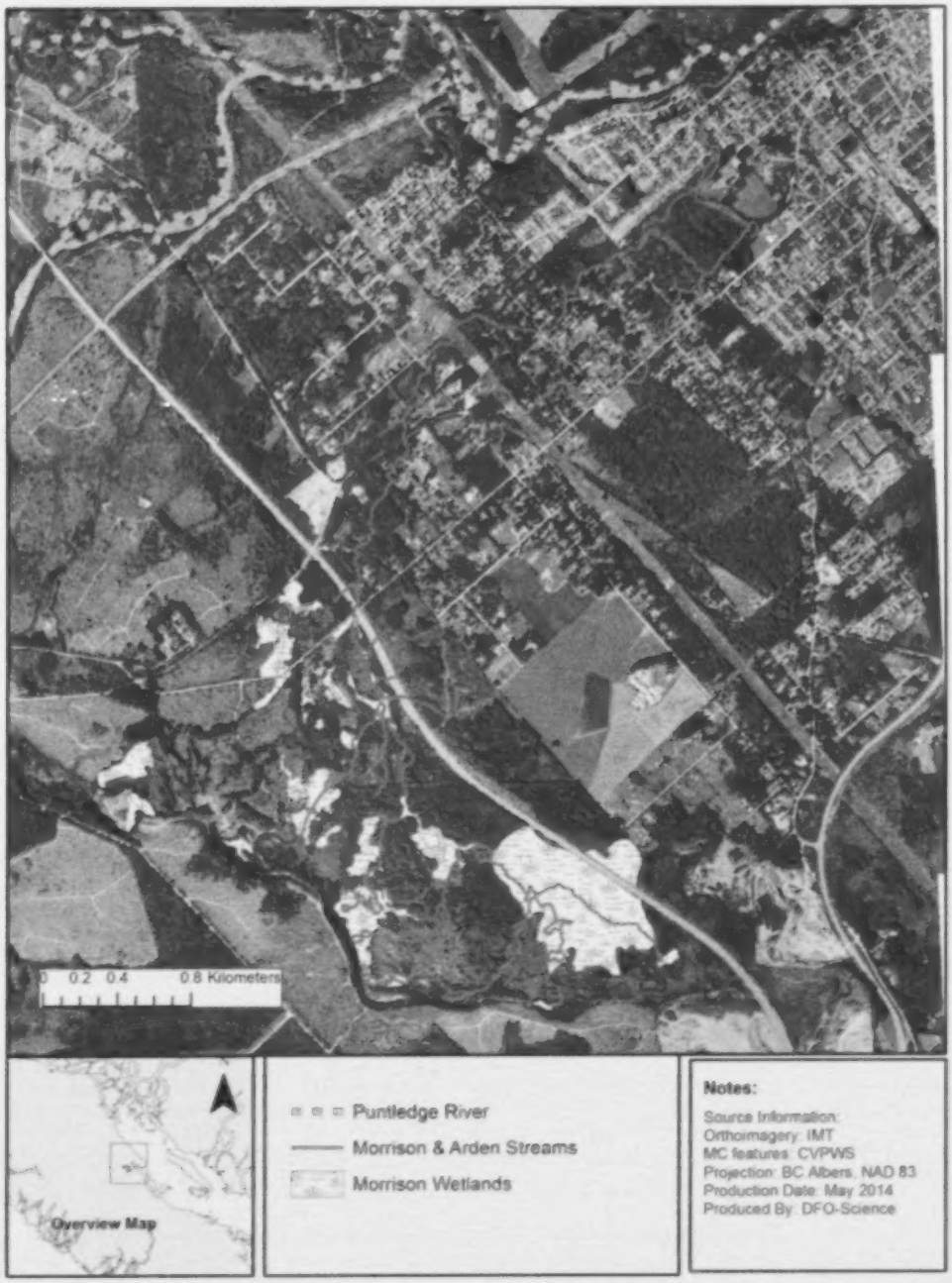

Figure 1. Morrison Creek watershed.

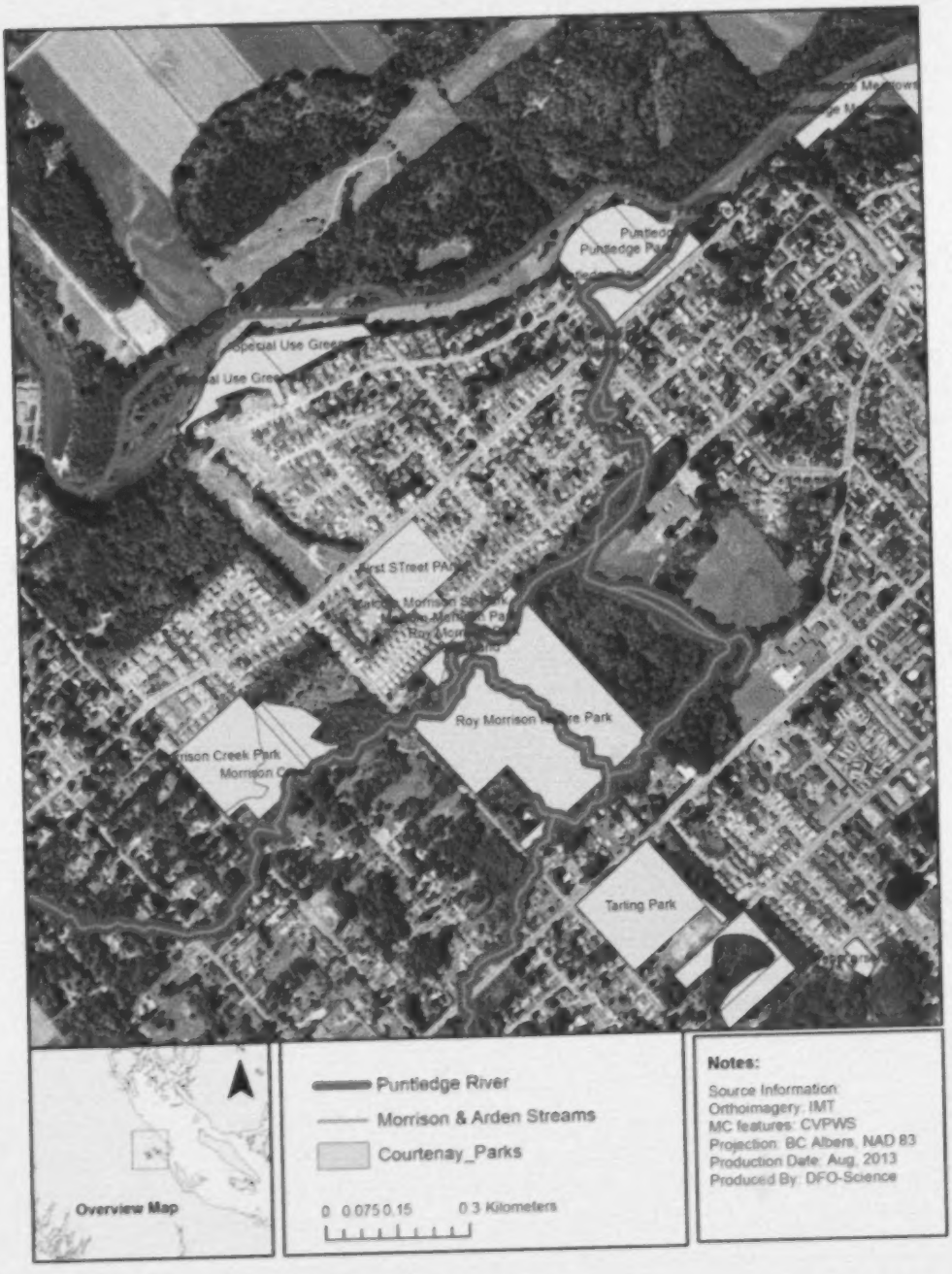

Figure 2. Arden Creek diversion channel and protected areas and parks.

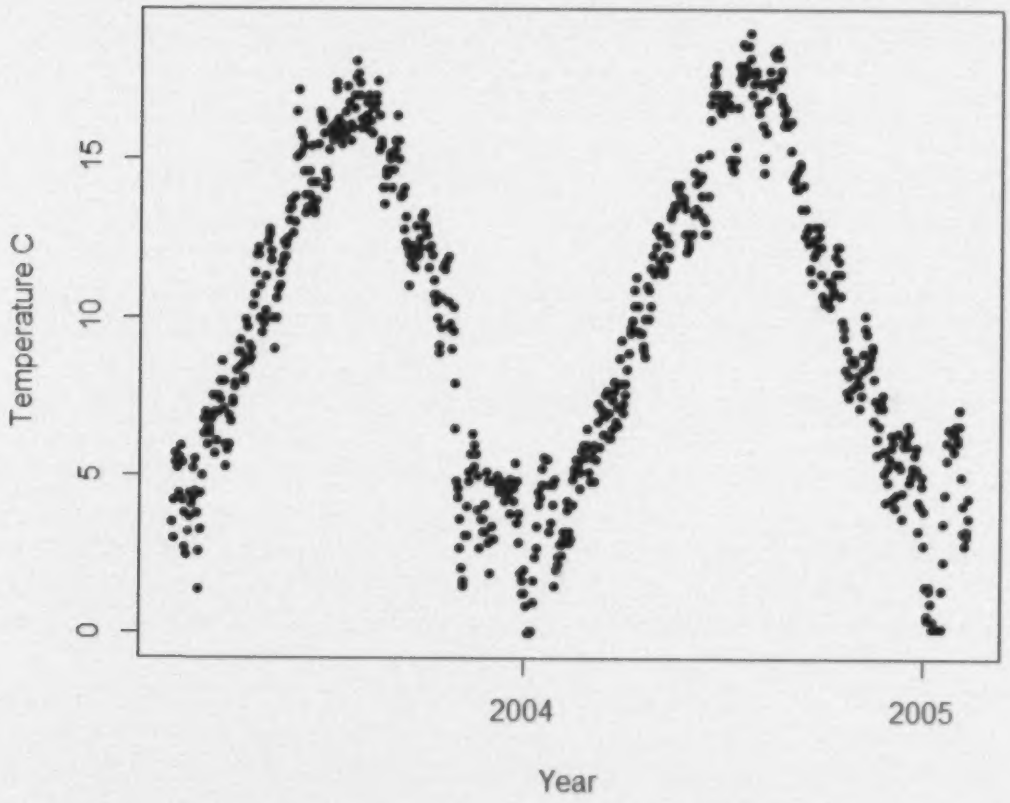

Figure 3. Average daily temperature for lower Morrison Creek from 2003-2005. (Data provided by Morrison Creek Streamkeepers).

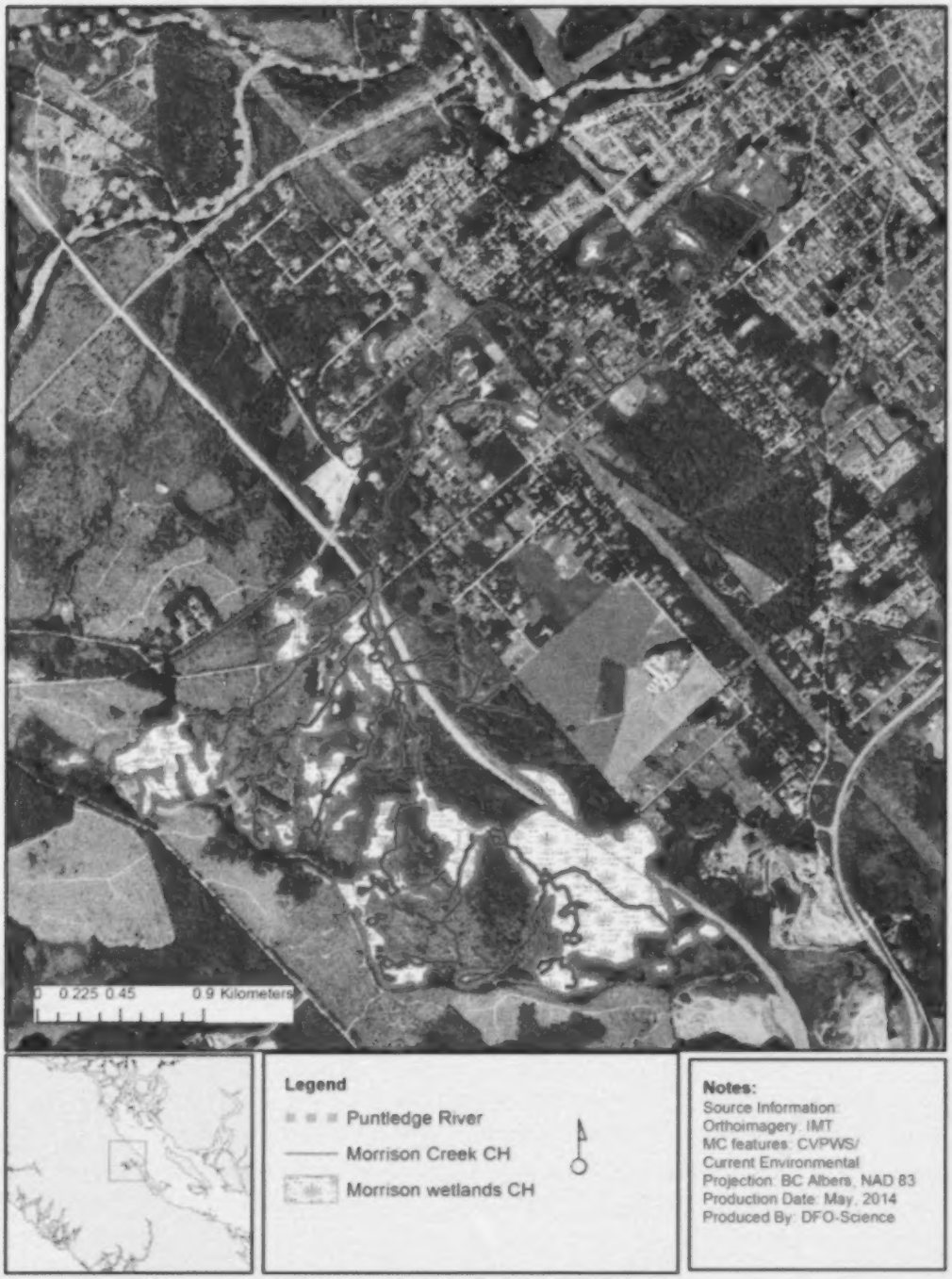

Figure 4. Proposed critical habitat (in red) for Morrison Creek Lamprey.